Manipulating sorghum agronomy to suppress summer grass weeds

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Abstract
Summer grass weeds awnless barnyard grass (*Echinochloa colona*) and feathertop Rhodes grass (*Chloris virgata*) are difficult to control in the summer crop sorghum. Both weeds have populations resistant to herbicides and there are few effective herbicide options for in-crop control. We manipulated the agronomy of sorghum in field trials by comparing cultivars, row spacing and crop density. The suppressive ability of different crop configurations was assessed by comparing their impact on growth and seed production of target weeds. Sorghum grown at a narrow row spacing (50 vs 100 cm) and increased crop density (10 vs 5 plants m^{-2}) reduced growth and seed production of both FTR and BYG. Weed biomass was reduced by 36-99 % and weed seed production by up to 90 % at a narrow row spacing. At a greater crop density, 39-63 % less biomass was produced and 41-56 % less weed seed was produced. The effect of sorghum cultivar was not consistent across sites.

Keywords
Crop competition, sorghum, weed control.

Introduction
Sorghum (*Sorghum bicolor*) is a summer grain crop commonly grown in the subtropical cropping region of Australia (northern NSW and Queensland). Sorghum is commonly grown on wide row spacing (1 m or greater) and sometimes in skip row configurations resulting in a space between rows of up to 2 m. This wide row spacing favours in-crop weeds. Two key weeds of the region are the summer grasses, feathertop Rhodes grass (*Chloris virgata*) (FTR) and awnless barnyard grass (*Echinochloa colona*) (BYG). Both species have populations confirmed as resistant to the commonly used herbicide glyphosate and recently one population of FTR has been confirmed as resistant to the Group A herbicide haloxyfop (Widderick et al. 2021). Being grass weeds, there are limited herbicide options for their control in sorghum, a grass crop, although there are some effective residual herbicides.

Sorghum has been identified as a weak link in the crop rotation cycle for these two weeds, enabling them to survive and reproduce. This paper presents recent research on the impact of manipulating sorghum agronomy (cultivar, row spacing and crop density) on the growth and seed production of FTR and BYG.

Methods
Replicate field trials were carried out at Kingaroy, Qld and Narrabri, NSW in the summer of 2019/20. Cultivars Rippa, Taurus and G33 were compared across narrow (50 cm) and wide (100 cm) row spacings and low (5 plants m^{-2}) and high (10 plants m^{-2}) crop densities.

The field trials were in a randomised complete block design with 4 replicates at Narrabri and 6 replicates at Kingaroy. Weeds were sown in fixed quadrats (2 m^{-2}) and the crop and weeds thinned to desired densities. Irrigation was applied as required to ensure establishment of the crop and weeds and no herbicides were applied for weed control. At crop maturity, weed seed production was calculated by counting weed seeds on representative seed heads multiplied by seed head number m^{-2}. Weed biomass was assessed by harvesting weeds from the quadrat and drying at 80°C until samples were dry (2-4 days). Crop yield was also assessed from each quadrat.

Results

The narrow sorghum row spacing (50 cm) reduced biomass (growth) of FTR by 40 and 93 % at Kingaroy and Narrabri respectively, when compare to the wide (100 cm) row spacing (Figure 1). The biomass of BYG was 36-45 % less at 50 cm row spacing at Kingaroy and 91-99 % less at Narrabri. Similarly, BYG seed production was reduced by 48 % at a narrow row spacing at Kingaroy and 90 % in Narrabri. A narrow row spacing had no effect on FTR seed production at Narrabri and at Kingaroy there was an interaction between row spacing and crop density (discussed below). A narrow row spacing resulted in a 24 and 26 % greater yield at Kingaroy and Narrabri, respectively.

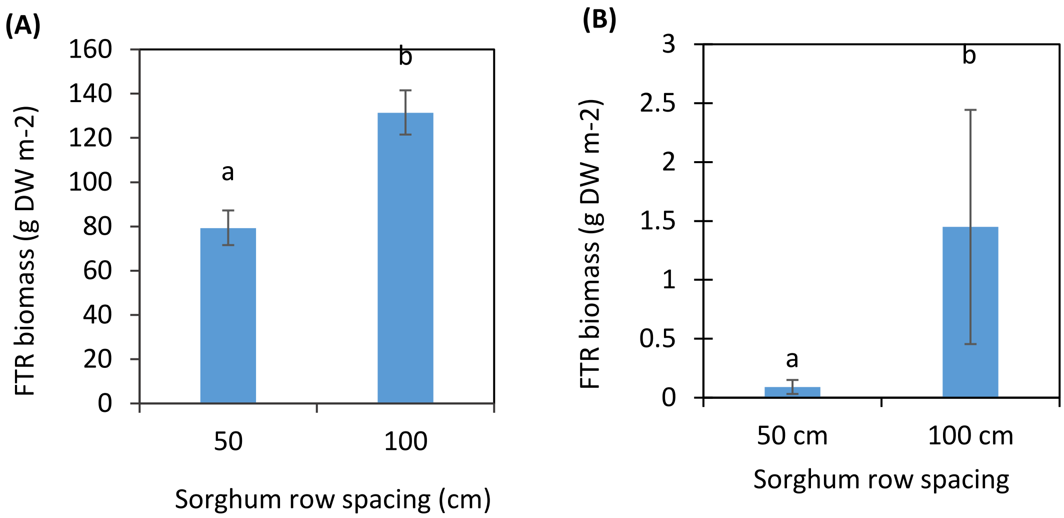

Figure 1. Influence of sorghum row spacing on Feathertop Rhodes biomass at (A) Kingaroy, Qld, and (B) Narrabri, NSW, 2019/20. Within each graph bars with a different letter are significantly different at P=0.05. Error bars represent back-transformed standard error of the means of (A) six and (B) four replicates. Data are (A) square root back transformed and (B) log back transformed.

A greater sorghum density (10 vs 5 plants m^{-2}) resulted in a 39 % lower FTR biomass and a 45 % lower BYG biomass at Kingaroy. The same effect was seen at Narrabri where the biomass of BYG was reduced by 63 % at the greater sorghum density. However, there was no effect of sorghum density on FTR biomass at Narrabri. A greater sorghum density resulted in a lower seed production with 56 % less FTR produced at Narrabri at a higher crop density and 41 % less BYG seed produced at Kingaroy (Figure 2). Sorghum density had no effect on BYG seed production at Narrabri. In the Kingaroy field trial, an increased sorghum density resulted in a 23-25 % increase in crop yield. There was no yield effect at Narrabri.

When combined, a narrow row spacing (50 vs 100 cm), and increased crop density (10 vs 5 plants m^{-2}) had an additive effect on suppressing FTR seed production at Kingaroy (Figure 3). At both sorghum densities, a reduction in row spacing to 50 cm resulted in a reduction in FTR seed production. However, the magnitude of this reduction was greater at the higher sorghum density (10 plants m^{-2}) where seed production was reduced by 51 % compared to 29 % in the lower crop density. A combination of narrow row spacing and higher sorghum density reduced FTR seed production by 64 % compared to wide row spacing (100 cm) and lower sorghum density (5 plants m^{-2}).

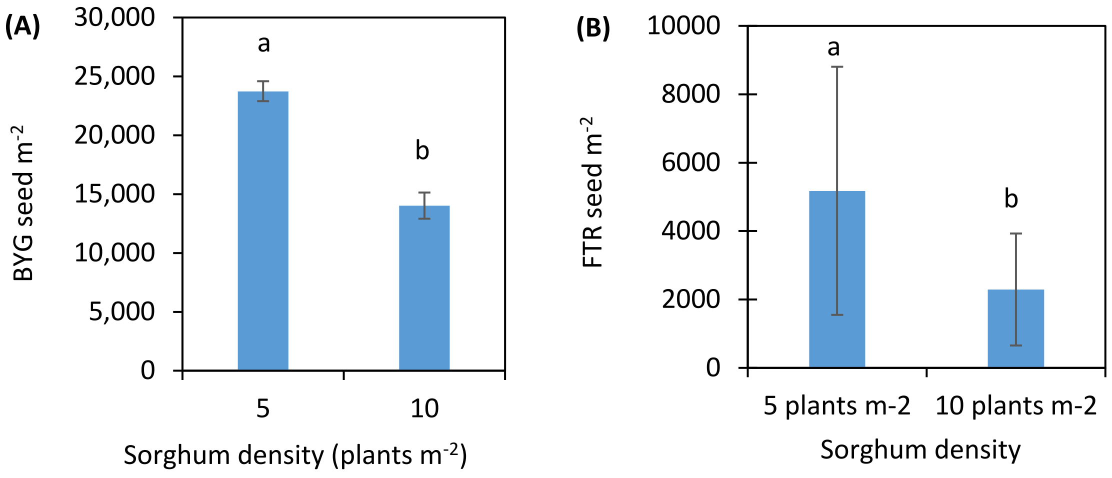

Figure 2. Effect of sorghum density on seed production of (A) BYG at Kingaroy, Qld and (B) feathertop Rhodes grass at Narrabri, NSW, 2019/20. Within each graph, bars with a different letter are significantly different at P=0.05. Error bars represent the back-transformed standard error of the means of (A) six and (B) four replicates. Data are (A) square root and (B) log back transformed.

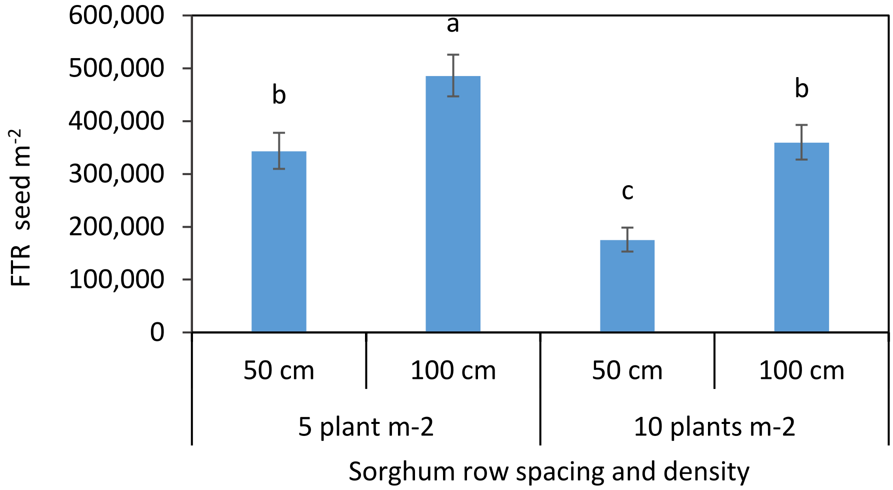

Figure 3. Influence of sorghum row spacing and density on Feathertop Rhodes grass seed production at Kingaroy, Qld, 2019/20. Bars with a different letter are significantly different at P=0.05. Error bars represent back-transformed standard error of the means of six replicates. Data are square root back transformed.

Sorghum cultivar had an impact on suppression of FTR and BYG at both sites. However, the effects were not consistent across sites. At Kingaroy G33 was the most suppressive cultivar, but at Narrabri it was the least suppressive. At Kingaroy, there were 18 % fewer FTR seeds produced in G33 than in Taurus and 17 % less biomass. Similarly, for BYG seed production was 24% less in G33 than in Taurus (Figure 4). Cultivar had no effect on BYG biomass at Kingaroy. In contrast, at Narrabri, FTR biomass was 75 % less when grown with cultivar Rippa or Taurus compared to G33 and BYG seed was 72 % and 75 % less when grown with cultivar Taurus and Rippa compared to G33 (Figure 4). At Narrabri there was no effect of cultivar on FTR seed production. . However, at Narrabri BYG biomass was 20% less in G33 than in Taurus.

Sorghum yield differed between cultivars and between sites. At Kingaroy, the most competitive cultivar, G33, yielded 10-13 % greater than the poorly competitive cultivar Taurus. However, at Narrabri, Taurus yielded 20 % more when compared to G33.

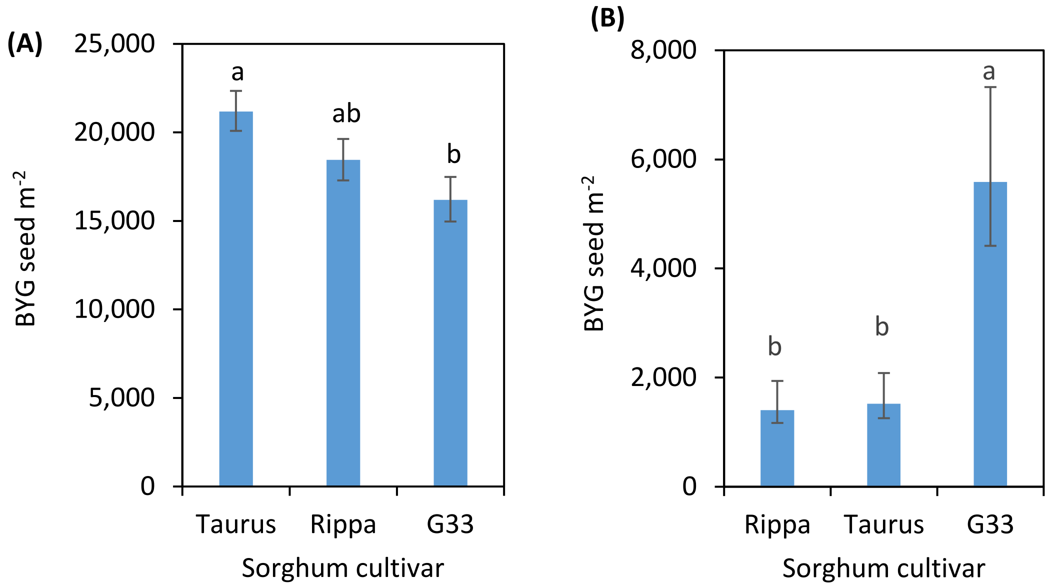

Figure 4. Barnyard grass seed production when grown in different sorghum cultivars at (A) Kingaroy and (B) Narrabri. Within each graph bars with a different letter are significantly different at P=0.05. Error bars represent the back-transformed standard error of the means of (A) six and (B) four replicates. Data are (A) square-root and (B) log back transformed.

Conclusion

Sorghum grown at a narrow row spacing (50 vs 100 cm) and increased crop density (10 vs 5 plants m^{-2}) was consistent across sites in reducing the growth and seed production of both FTR and BYG. Biomass was reduced by 36-99 % and seed production by up to 90 % at a narrow row spacing. At a greater crop density, 39-63 % less biomass was produced and 41-56 % less weed seed was produced. A narrow row spacing, and increased crop density also increased crop yield by 23-26 % in this irrigated environment. This effect may be different in a water limiting environment.

The cultivar effects were different across the trials. Cultivars are often better suited to a particular environment and it is therefore not unexpected to see this difference. The results do however show that cultivar choice is likely to have an effect on the suppression of these in crop weeds.

A competitive sorghum crop (narrow row spacing, increased crop density and regionally suited cultivar) can greatly suppress the growth and seed production of FTR and BYG. However, to maximise weed control, a competitive crop should be used in combination with other effective weed control tactics such as residual herbicides, harvest weed seed control and ensuring low weed densities prior to planting the crop.

References

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